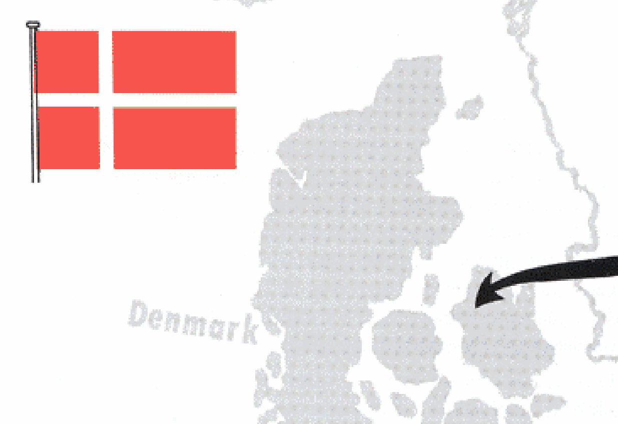
ADRE® for Windows saves a generator

Proximity probes installed for more accurate data



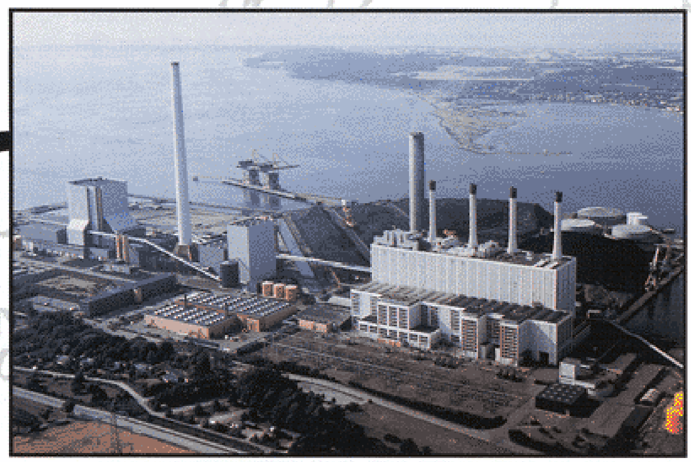


Photo courtesy of Sjællandske Kraftværker.

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The Asnæs Power Station, located on the Kalundborg Fjord in eastern Denmark, is Denmark's largest power station. Owned by SK Power, it supplies electricity to the Zealand grid, heat to the Kalundborg Municipality and process steam to neighboring companies. Its five thermal units use coal, but can also be fired with oil. With a total generating capacity of 1500 MW, Asnæs Power Station can supply 60% of eastern Denmark's electricity demand.

Asnæs' Unit No. 1 consists of a high pressure (HP) turbine, intermediate turbine (IP), combined intermediate and low pressure turbine (IP/LP), and a generator (Figure 1). Since its commissioning in 1959, Unit 1 has operated approximately 200,000 hours. In 1985, it was rebuilt and upgraded to 150 MW. The HP and IP turbines were replaced, the combined IP/LP turbine had new turbine blades installed, and the two-pole generator windings and retaining rings were also replaced.

Casing vibration was measured with velocity probes integrated to indicate displacement. Normal vibration was 28 to 56 μm (1.1 to 2.2 mils) peak to peak displacement. The unit has had 250 starts in the 30,000 operational hours since it was rebuilt. High vibration was normal during these startups. However, after a startup in January 1994, vibration levels increased significantly. During loading, vibration levels came close to the unit's trip point of 120 μm (4.8 mils) peak to peak displacement.

Bently Nevada Norge A/S provided us with the equipment we used to analyze this problem. We collected vibration and process data with two Bently Nevada 208 Data Acquisition Interface Units (DAIU), and reduced and plotted the data with Bently Nevada ADRE® for Windows Software. The 208 DAIU is an eight-channel data collection and processing unit. ADRE® for Windows is sophisticated

vibration diagnostics software that works with Microsoft® Windows. Together, the system collects machine vibration and process data during transient and online operation and displays multiple plots simultaneously. Casing transducers supplied most of the vibration information. The process variables we measured included rotor current, hydrogen cooling temperature and lubrication and generator oil seal temperatures.

During a startup, we used the ADRE for Windows System to acquire and plot vibration data from the velocity transducers mounted on each bearing housing. We identified balance and structural resonances that we attributed to various machine train components. However, we could not conclusively identify the source of increased vibration from this data.

We increased rotor exciter current from 800 to 1300 amperes, and after approximately 30 minutes, we saw a corresponding increase in 1X vibration with a constant phase angle (Figures 2 and 3). 1X vibration was dominant in Unit No. 1, especially on its generator bearings, Bearings 4 and 5. From this, we concluded that the high vibration was originating in the generator.

Each pole in the generator has eight windings. Each winding consists of 18 copper bars. The bars are indirectly cooled by heat transfer to the rotor body. A single bar on top of the upper copper bar is called the "damping winding bar." Retaining rings hold the generator windings in place at each end of each pole. Electrical insulation between the retaining rings and generator windings prevents the windings from shorting on the retaining rings (Figure 4). We suspected either that grooves in the damping winding bar were pressing against the retaining rings or that the indirectly-cooled copper bar windings were pressing against the backplate of the retaining rings.

When Asnæs' staff overhauled Unit No. 1, the generator was opened and the generator rings were dismantled on site. ►

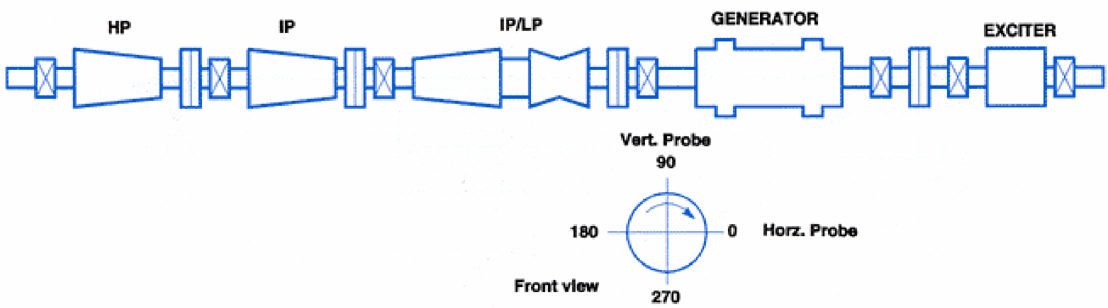

Figure 1:
Asnæs Turbine Unit 1 machine train diagram.

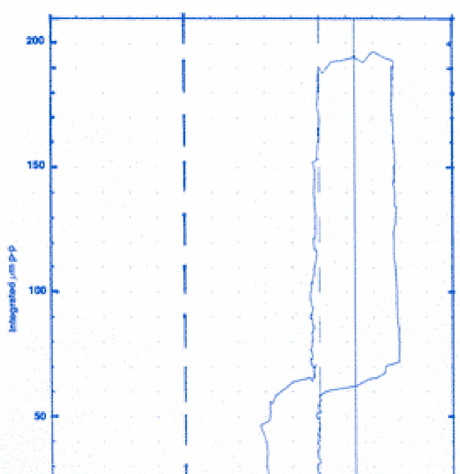

Figure 2:
Exciter current versus Bearing 4 vertical velocity transducer vibration. Approximately 30 minutes after exciter current is increased from 800 to 1300 amperes, vibration increases.

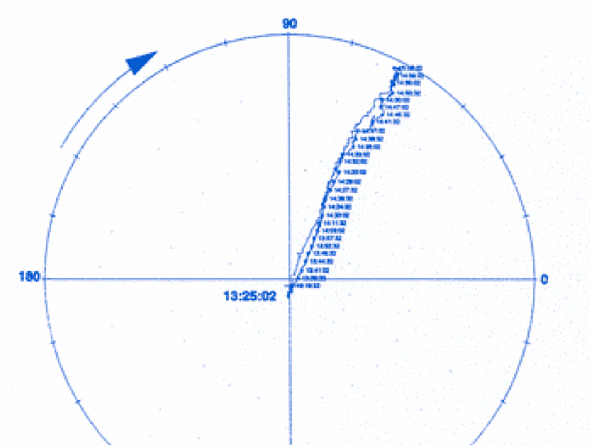

Figure 3:
Same data as Figure 2. As exciter current is increased from 800 to 1300 amperes, vibration at Bearing 4 increases with no change in phase angle.

Analysis

When we inspected the generator rotor, we saw that the generator windings were displaced axially by approximately 10 mm (394 mils) (Figure 5). The winding coils at one pole were pressing toward the retaining ring backplate, yielding unsymmetrical axial forces that preloaded and bent the rotor body, causing the increased 1X vibration. Further axial displacement could have led to a winding short circuit, as two of the windings were close to each other. This could have caused a more severe generator failure.

The rotor is currently under repair at Asnæs Power Station (Figure 6). Three OEM specialists and 18 Asnæs Power Station employees are working in three shifts dismantling, straightening and reinstalling 12 of the 16 winding coils. We are modifying the bearing housing to reduce its structural resonance. **We also decided that we need better vibration information than can be provided by seismic, housing-mounted probes. On machines with fluid-film bearings, much of the energy generated by machine malfunctions is not transmitted to housing-mounted transducers. Proximity probes that directly observe the rotor provide much better diagnostic information. Therefore, in addition to seismic probes, we are installing XY proximity probes on each bearing.**

After repair, the rotor will be transported to the manufacturer for balancing. Asnæs Power Station staff will field-balance the unit using Bently Nevada's ADRE® for Windows Software, 208 DAIU and Multiplane Balancing Software.

Conclusion

ADRE for Windows helped us correlate Unit No. 1's increased vibration with changes in rotor exciter current. Our knowledgeable personnel used this information to locate and repair the problem before it became more serious. The new proximity probes we are installing will give our staff more accurate data with which to analyze future machine problems. ■

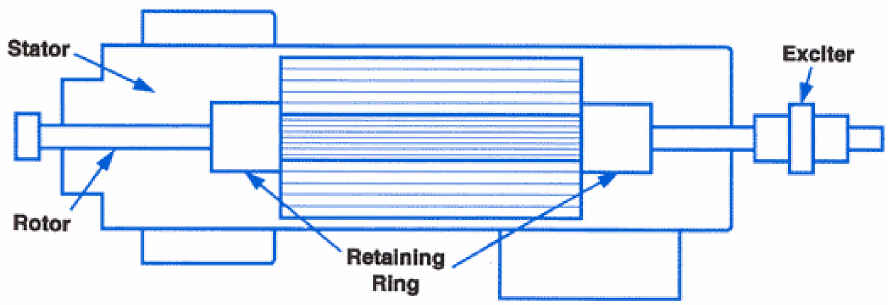

Figure 4:
Cutaway drawing of generator showing windings and retaining rings.

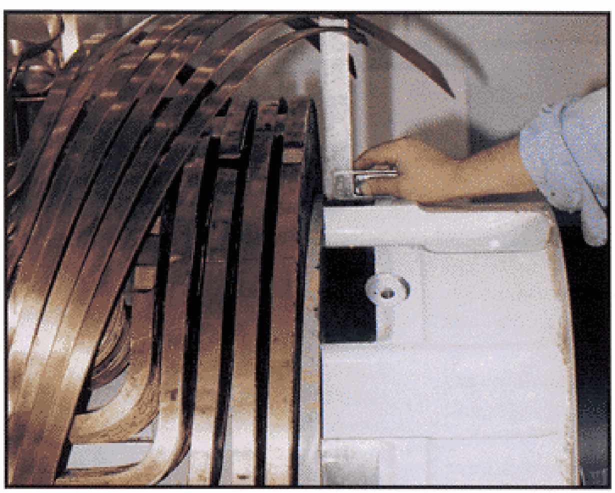

Figure 5:
Disassembled generator, viewed from non-driven end. The winding coils are pulled toward the driven end. The retaining ring has been pulled back to reveal the windings. The top winding is the damping coil, shown partially disassembled.

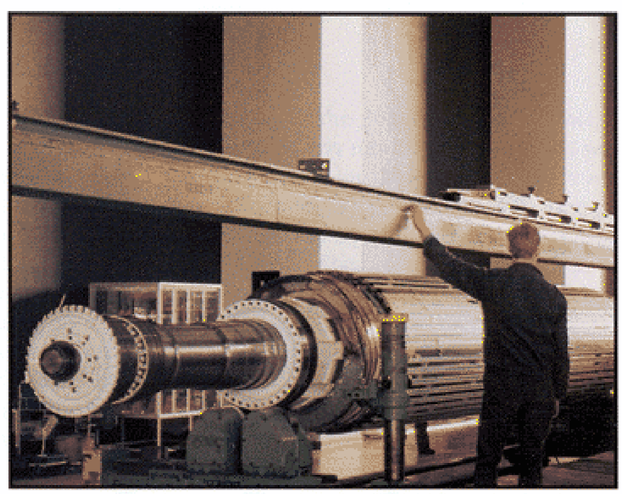

Figure 6:
Generator rotor with dismantled retaining rings.